Calibration of a Large-Scale Groundwater Flow Model Using Transient Pressure Data

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RESEARCH OBJECTIVES

It is quite challenging to build a reliable model for simulating groundwater flow in a large body of rock mass, particularly when the rock is fractured. Large-scale groundwater flow models are typically calibrated to the steady-state pressure head data. However, because steady-state head data are largely controlled by the boundary conditions and less sensitive to the permeability structure, they alone are not sufficient for building a reliable predictive model. Large-scale, active stressing of the system can help greatly increase the reliability of the model. The overall objective of this project is to develop a methodology for reducing the uncertainty and increasing the reliability of such a model.

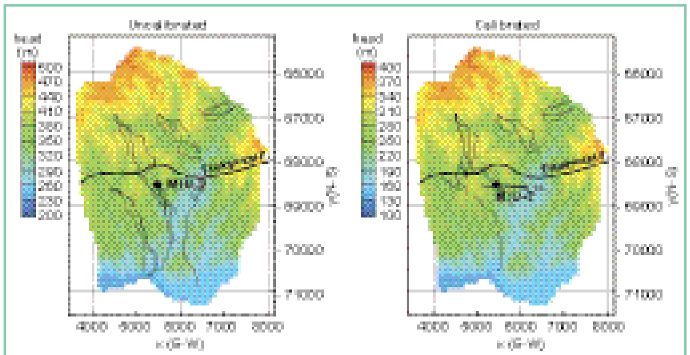

Figure 1. Particle trajectories before and after calibration. Travel times increase by a factor of 100 primarily due to decreases in permeability and increases in porosity. Well MIU-2 and the surface trace of the Tsukiyoshi fault are also shown. Well MIU-2 intersects the fault at a depth of approximately 1,000 m.

APPROACH

Starting with regional geographic, geologic, surface and subsurface hydrologic, and geophysical data for the Tono area in Gifu, Japan, we developed an effective continuum model to simulate subsurface flow and transport in a 4 km × 6 km by 3 km thick fractured granite rock mass overlain by sedimentary layers. Continuum permeability and porosity distributions are assigned stochastically, based on well-test data and fracture density measurements. Lithologic layering and one major fault—the subvertical, E-W striking, Tsukiyoshi Fault—are assigned deterministically. Well MIU-2 penetrates through the Tsukiyoshi fault, and when a packer system was removed prior to long-term pump tests, the open wellbore provided a high-permeability pathway for flow from the high-head foot wall, to the lower-head hanging wall. The pressure in the foot wall declined, and the pressure in the hanging wall increased in response. Thus, the removal of the packer effectively created two simultaneous well tests. We use this transient pressure response to the packer removal in Well MIU-2, in addition to the steady-state hydraulic head profiles of several wells in the MIU area, to calibrate the model. The calibrated model is then used to predict travel times from specified monitoring points to the model boundaries.

ACCOMPLISHMENTS

We successfully constrained a groundwater flow model by using transient pressure data. The disturbance caused by the removal of a packer string in effect served as an inadvertent large-scale well test. We concluded that the effective porosity of granite may be one to two orders of magnitude larger than that previously predicted. The calibration process serves to lengthen the travel times through the model by a factor of about 100.

SIGNIFICANCE OF FINDINGS

Large-scale pressure tests may be an effective tool for estimating the large-scale porosity of a large body of granite.

RELATED PUBLICATION

Doughty, C., and K. Karasaki, Constraining a fractured-rock groundwater flow model with pressure-transient data from an inadvertent well test. In: Proceedings of the Second International Symposium on Dynamics of Fluids in Fractured Rock, 2004. Berkeley Lab Report LBNL-54275.

ACKNOWLEDGMENTS

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